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C. Bacci, R. Baldini-Celio, G. Capon, R. Del Fabbro, M. Grilli, E. Iarocci, M. Locci, C. Mencuccini, G. P. Murtas, G. Penso, M. A. Spano, M. Spinetti, B. Stella and V. Valente :

SEARCH FOR THE RADIATIVE $\eta'(958)+\gamma$ DECAY OF THE $J/\psi(3100)$ RESONANCE PRODUCED IN e^+e^- ANNIHILATION.

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ABSTRACT. -

The decay J/ψ (3100) $\longrightarrow$ $\eta'(958)+\gamma$ has been searched for at the Adone e^+e^- storage ring. No candidate event has been found. This allows to set an upper limit of 1.0 KeV (90% c. l.) for this decay partial width.

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We report on a research performed at ADONE, the Frascati e^+e^- storage ring, on the reaction:

(1) $$e^+e^- \rightarrow \eta' \gamma$$

at the energy of the J/ψ (3100) resonance. The η' is the pseudo-scalar meson of mass 958 MeV and total width < 1 MeV. This work is part of a research program on the radiative decays of the J/ψ (3100) resonance[1]. Within the limits of the collected statistics, we find no evidence for the existence of the reaction (1) and give the following upper limit for the partial decay width $\Gamma(J/\psi\ (3100) \rightarrow \eta'\gamma) < 1,0$ KeV (90% c.l.).

The experimental set-up has been already described elsewhere[2]. It consists of two large semi-cylindrical telescopes located above and below the interaction region with their axes perpendicular to the beam line. These telescopes consist of scintillation counters and optical spark chambers with lead and iron absorbers in between, arranged in such a way to optimize electromagnetic shower detection[1]. This part of the set-up covers a total solid angle, for a point-like source, of (0,41x x 4π) sr for trigger and (0,66 x 4π) sr for tracking. The trigger logic asks for at least one charged particle in the upper telescope and either at least one charged particle or one photon in the lower telescope. In addition to the two main upper and lower telescopes, a pair of circular side-telescopes (magnetostrictive read-out spark chambers, absorbers and scintillation counters) complement the system covering a further fraction of total solid angle of (0,15 x 4π) sr , for point-like source. The absolute luminosity of the machine was measured by the small angle ($3^o \div 6^o$) Bhabha scattering and the double bremsstrahlung, as detected with a monitoring apparatus installed in a different interaction region of Adone.

In order to study the reaction (1), we have looked for the decay chain:

$$J/\psi\ (3100) \rightarrow \eta'\gamma$$
$$\hookrightarrow \varrho\ \gamma$$
$$\hookrightarrow \pi^+\pi^-$$

This decay mode has a rather large branching ratio ($\Gamma(\eta' \to \varrho\gamma)$ / $\Gamma(\eta' \to \text{all}) \simeq 27\%$) and allows efficient kinematical discrimination against multihadronic background. The selected decay chain leads infact to final states in which only four particles (two pions and two photons) are present, with one of the photons monochromatic and very energetic (1,4 GeV).

The present analysis refers to a sample of multihadronic events collected around the peak energy of the $J/\psi(3100)$ resonance for a total integrated luminosity of 9 nb^{-1}. In order to minimize background effects due to the various multihadronic decay channels, we have selected the following configuration in the optical spark chamber: 2 charged prongs + 2 photons or 2 charged prongs+ 1 photon, where the two charged prongs are in the same telescope. The detection efficiency for each of these two configurations is about 2%, according to a MonteCarlo calculation taking into account the proper angular distributions of the decay products. The energy of the detected photons can be roughly estimated on the basis of the track-length and spark pattern of the shower in the spark chambers. This rough energy calibration can be continuously tested by observing the features of the showers from the reactions $e^+e^- \to e^+e^-$, $e^+e^- \to \gamma\gamma$ and $e^+e^- \to e^+e^-\gamma$, which are simultaneously detected by the set-up.

The initial sample of analyzed events consisted of 6 events with 2 charged prongs + 1 photon and 19 events with 2 charged prongs + 2 photons ("complete configuration"). The condition that no other charged particle was detected in the non-optical part of the set-up (side-telescopes and anticoincidence counters), left us with no event with 2 charged prong + 1 photon, and 10 events with 2 charged prongs + 2 photons. On these 10 candidate events for the "complete configuration", the following sequence of selection criteria has been then applied.

i) Starting from the measured angles of the four detected particles, the momentum balance condition has been tested, thus selecting events consistent with the assumption that no other particles were produced and escaped detection. Five events satisfying

this criteria were left. For these events, the momenta of the four particles have been calculated under the assumption that the charged prongs were pions. In order to look for the decay $J/\psi\,(3100) \to \eta'\gamma$, $\eta' \to \varrho\ \gamma$, for each event we have calculated the invariant masses of the assumed pion pair $M(\pi^+, \pi^-)$ and of the $\pi^+\pi^-\gamma$ system $M(\pi^+, \pi^-, \gamma)$, where γ is the less energetic of the two detected photons, according to the calculated energy from the kinematical reconstruction. The resulting scatter plot is shown in fig. 1.

ii) A further selection criterion required that $M(\pi^+, \pi^-)$ and $M(\pi^+, \pi^-, \gamma)$ were consistent with the masses of the ϱ and η' mesons respectively. Taking into the account the angular resolution of the measurement and the ϱ mass width, events fulfilling the above conditions should appear, with 95% probability, inside the dashed area shown in the scatter plot of fig. 1 . Only one candidate was left after the application of the above mentioned selection criteria. This event has been ruled out on the basis of a clear inconsistency between the calculated energy ($\sim$ 50 MeV) and the observed features on the detected shower.

The final result is that we are left with no event in both the selected configurations. This allows us to derive the following upper limit for the ratio:

$$\frac{(J/\psi \to \eta'\gamma)}{(J/\psi \to \text{many hadrons})} < 1,7\% \qquad (90\%\ \text{c.l.}).$$

From the knowledge of the particle width $\Gamma(J/\psi \to \text{many hadrons})$[3], the following upper limit can be set for the partial decay width

$$\Gamma(J/\psi\,(3100) \to \eta'\gamma) < 1.0\ \text{KeV} \qquad (90\%\ \text{c.l.}).$$

* * *

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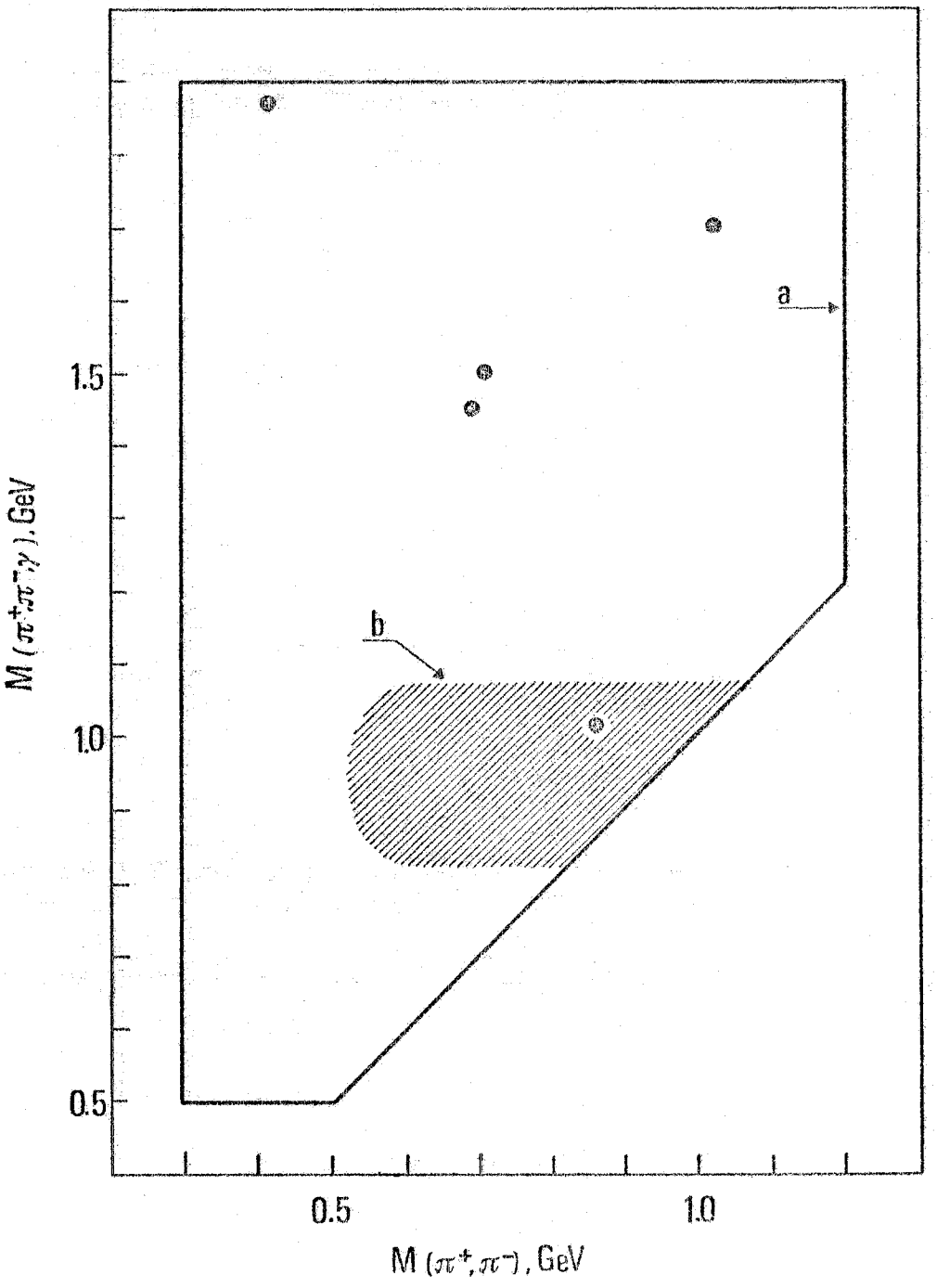

FIG. 1 - Scatter plot of the invariant mass M(π^+, π^-) of the pion pair versus the invariant mass M(π^+, π^-, γ), γ being the less energetic detected photon, for the events satisfying the momentum balance. The area limited by the solid line (a) represents the geometrical and trigger acceptance of the apparatus for two prongs and two photons isotropically distributed. The dashed area (b) represents the acceptance of apparatus for 95% of the events from the decay $J/\psi\,(3100) \rightarrow \eta'\gamma$, with $\eta' \rightarrow \varrho\,\gamma$, taking into account the experimental angular resolution and the ϱ width.

REFERENCES -

(1) - C. Bacci, G. Penso, B. Stella, R. Baldini-Celio, M. Bernardini, M. Bozzo, G. Capon, R. Del Fabbro, M. Grilli, E. Iarocci, L. H. Jones, C. Mencuccini, G. P. Murtas, M. Spinetti and V. Valente. Lett. Nuovo Cimento, 12, 269(1975)

(2) - R. Baldini-Celio, M. Bernardini, G. Capon, R. Del Fabbro, M. Grilli, E. Iarocci, L. H. Jones, M. Locci, C. Mencuccini, G. P. Murtas, M. A. Spano, M. Spinetti, V. Valente, C. Bacci, V. Bidoli, G. Penso and B. Stella.
Lett. Nuovo Cimento, 11, 711(1974)

(3) - A. M. Boyarski, M. Breidenbach, F. Bulos, G. J. Feldman, G. E. Fischer, D. Fryberger, G. Hanson, B. Jean-Marie, R. R. Larsen, D. Luke, V. Luth, H. L. Lynch, D. Lyon, C. C. Morehouse, J. M. Paterson, M. L. Perl, P. Rapidis, B. Richter, R. F. Schwiters, W. Tanenbaum, F. Vannucci, G. S. Abrams, D. D. Briggs, W. Chinowsky, C. E. Friedberg, G. Golhaber, J. A. Kadyk, A. M. Litke, B. A. Lulu, F. M. Pierre, B. Sadoulet, G. H. Trilling, J. S. Whitaker, F. Winkelmann and J. E. Wiss.
Phys. Rev. Letters, 34, 1357(1975)

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